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Effects of Li, Ca, Fe, and B on NaAlSiO_4 nepheline crystallization in high level waste glasses

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Owing to high concentrations of Al_2O_3 from dissolved fuel cladding and Na_2O from basification of the waste, about half of the high-level waste by volume at Hanford, Washington, USA is rich in both Na and Al. Formulations of high waste-loading glasses result in lower amounts of SiO_2 , which often leads to undesirable precipitation of nepheline (NaAlSiO_4). Nepheline crystallization can be affected by modifiers (Li, Ca) added to lower viscosity and improve electrical conductivity of the melt. Also, B is frequently added to reduce viscosity, and Fe is present in varying amounts from steel tank corrosion. Given the existence of various natural minerals of the stoichiometries $(\text{Na,Li,Ca}_{0.5})(\text{Al,Fe,B})\text{SiO}_4$, we sought to study the effects of substitution in the stoichiometric nepheline glass on the resulting crystallization. We summarize here several years of work, including characterization by nuclear magnetic resonance, vibrating sample magnetometry, Raman spectroscopy, thermal analysis, x-ray diffraction, electron microscopy, and electron microprobe.

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